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ASPHALT PAVEMENT MATERIAL IMPROVEMENT: A REVIEW

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ABSTRACT

From the beginning of asphalt mixture design it was desired to understand the interaction of aggregates, asphalt, and the voids created during their compaction. In asphalt mixture design, guidance is lacking in the selection of the design aggregate structure and understanding the interaction of that aggregate structure and mixture volumetric properties. This paper presents mixture design concepts that utilize aggregate interlock and aggregate packing to develop an aggregate blend that meets volumetric criteria and provides adequate compaction characteristics. The presented concepts rely on coarse aggregate for the skeleton of the mixture with the proper amount of fine aggregate to provide a properly packed aggregate structure. The objective is to utilize aggregate packing concepts to analyze the combined gradation and relate the packing characteristics to the mixture volumetric properties and compaction characteristics. The presented concepts include an examination of aggregate packing and aggregate interlock, blending aggregates by volume, a new understanding of coarse and fine aggregate, and an analysis of the resulting gradation. This study presents comprehensive mix analysis concepts for developing and analyzing hot mix asphalt gradations. It is presented through a rational approach to the selection of relative amounts of coarse and fine aggregate. Evaluation of gradation with aggregate ratios provides a new tool for examining aggregate gradations. These ratios, based on particle packing, provide distinct relationships with the resulting mixture volumetrics and compaction characteristics. The results of this study improve the state-of-the-art in asphalt mix design and production by providing a method to characterize HMA mixture volumetrics and compaction characteristics through the fundamental principles of particle packing. The design concepts outlined in this study provide the foundation for a comprehensive asphalt mixture design method: The Bailey Method of Gradation Analysis and Asphalt Mix Design.

Keywords: Asphalt, Crumb rubber tires, Waste plastics.

1. INTRODUCTION

Having a long past of bituminous roads (flexible pavement) in India, due to repeated resurfacing as a periodic maintenance many pavements / roads have reached to higher raised level as compared to adjoining / abutting properties in old urban areas. The problem has reached to a saturated level and needs to be addressed effectively. The raised level of the pavements can be lowered down up to desired and feasible depth with sophisticated milling machines and then after the same can be resurfaced with suitable wearing coat. The only objectionable part in the above method is that by introducing milling item, there is an addition of cost to the prevailing resurfacing methods and hence many authorities of urban areas are not adopting it.

Any improvement in service life of road pavements will be off course of a great economical advantage and any modifications of asphalt are attempts to extend the service life and improve the performance of asphalt pavements. The global problem with landfill disposal of automobile tires and plastics can only be solved by the feasible option left, and that is recycling and utilization of the recycled products. It is thought that the application of recycled automobile tires and plastics will not only solve the environmental of these industrial solid wastes problem but also act as very promising modifiers for the improvement of asphalt pavement material. Rokade S., (2012) has investigated the utilization of waste rubber tires and waste plastics in pavement of flexible highway, as a result he has concluded that the project is not only to improve the engineering properties of asphalt, but also allows us to collect modifier raw materials (plastics or crumb rubber) at low costs and provide a solution to the ecological menace imposed by the increase disposal of waste tires and plastics.

2. HISTORY OF ASPHALT MIX

The story of asphalt begins thousands of years before the founding of the United States. Asphalt occurs naturally in both asphalt lakes and in rock asphalt (a mixture of sand, limestone and asphalt). The ancient Mesopotamians used it to waterproof temple baths and water tanks. The Phoenicians caulked the seams of their merchant ships with asphalt. In the days of the Pharaohs, Egyptians used the material as mortar for rocks lay along the banks of the Nile to prevent erosion, and the infant Moses' basket was waterproofed with asphalt. In **625 B.C.** The first recorded use of asphalt as a road-building material in Babylon. The ancient Greeks were also familiar with asphalt. The word asphalt comes from the Greek "asphalts," meaning "secure." The Romans used it to seal their baths, reservoirs and aqueducts. **In 1595** Europeans exploring the New World discovered natural deposits of asphalt. Sir Walter Raleigh described a "plain" (or lake) of asphalt on the island of Trinidad, near Venezuela. He used it for recaulking his ships. **Early 1800s** Thomas Telford built more than 900 miles of roads in Scotland, perfecting the method of building roads with broken stones. His contemporary, John Loudon Macadam, used broken stone joined to form a hard surface to build a Scottish turnpike. Later, to reduce dust and maintenance, builders used hot tar to bond the broken stones together, producing "tar macadam" pavements. In **1870** Belgian chemist Edmund J. DeSmedt laid the first true asphalt pavement in the U.S. in Newark, N.J. DeSmedt also paved Pennsylvania Avenue in Washington, D.C. – using 54,000 square yards of sheet asphalt from Trinidad Lake. The Cummer Company opened the first central hot mix production facilities in the U.S. The first asphalt patent was filed by Nathan B. Abbott of Brooklyn, N.Y. in 1871. **In 1900** Frederick J. Warren filed a patent for "Bitulithic" pavement, a mixture of bitumen and aggregate ("bitu" from "bitumen" and "lithic" from "lithos," the Greek word for rock). The first modern asphalt facility was built in 1901 by Warren Brothers in East Cambridge, Mass. **In 1907** Production of refined petroleum asphalt outstripped the use of natural asphalt. As automobiles grew in popularity, the demand for more and better roads led to innovations in both producing and laying asphalt. Steps toward mechanization included drum mixers and Portland cement concrete mechanical spreaders for the first machine-laid asphalt. **In 1942** During World War II, asphalt technology greatly improved, spurred by the need of military aircraft for surfaces that could stand up to heavier loads. In **1955** The National Bituminous Concrete Association (forerunner of the National Asphalt Pavement Association or NAPA) was founded. One of the first activities: a Quality Improvement Program, which sponsored asphalt testing at universities and private testing labs. **In 1956** Congress passed the Interstate Highways Act, allotting $51 billion to the states for road construction. Contractors needed bigger and better equipment. Innovations since then include electronic leveling controls, extra-wide finishers for paving two lanes at once and vibratory steel-wheel rollers. **In 1970s** The national energy crisis underscored the need for conservation of natural resources. Since that time, an increasing amount of recycled asphalt has been incorporated in mixes. Today, asphalt pavement is America's most recycled material with more than 70 million metric tons of asphalt paving material is recycled each year. **In 1986** NAPA established the National Center for Asphalt Technology (NCAT) at Auburn University, Alabama, providing a centralized, systematic approach to asphalt research. NCAT recently opened a new research center and test track and is now the world's leading institution for asphalt pavement research. **In 2002** The EPA announced that asphalt plants are no longer on its list of industries considered major sources of hazardous air pollutants.

3. LITERATURE REVIEW

Bejarano et al conducted static triaxial tests on one RAP and two different aggregate materials. Individual RAP and aggregate specimens were compacted at OMC and 95% and 100% of maximum wet density (MWD) according to Caltrans specification CTM 216. Static triaxial tests were conducted at confining pressures of 0, 35, 70 and 105 kPa. After comparing the shear strengths of the RAP and aggregate, it was determined that the shear strength calculated for the RAP was comparable in magnitude to shear strengths calculated for the representative aggregate materials. This shear strength correlation was valid at both 95% and 100% MWD and each of the four confining pressures. Bejarano also conducted stiffness tests for the three materials according to SHRP test protocol P-46. Of the three tested materials, the RAP had a higher resilient modulus than the two aggregate materials tested at 95% and 100% MWD. When the compaction level was increased from 95% to 100%, the resilient modulus of the RAP and one of the aggregate materials increased. This change in compaction level had no affect on the resilient modulus of the second aggregate material. Lime stabilized RAP specimens cured for 7 days had a higher resilient modulus than the non-stabilized material in all cases.

Bennert et al conducted a similar test in which the shear strength of pure (100%) RAP and RCA were evaluated against the shear strength of a dense graded aggregate base course (DGABC) typical of the area the recycled materials would be used. Static triaxial test results for the pure samples indicate that the aggregate alone had higher shear strength than either RAP or RCA alone. Stiffness tests were also conducted on blends of the materials used in the study. Specimens were prepared combining the aggregate with RAP and RCA percentages of 100%, 75%, 50%, 25% and 0% (100% aggregate). Contraray to the strength behavior, it was found that as the amount of recycled material in the blend increased, the resilient modulus of the blended material also increased. Pure (100%) specimens of RAP and RCA had higher resilient modulus values than pure specimens of the virgin aggregate.

Guthrie et al evaluated the effects of RAP content on the shear strength of base course materials using the California Bearing Ratio test. Two RAP and two aggregate materials (one recycled and one virgin) were acquired for the test. Specimens were prepared at RAP percentages of 100%, 75%, 50%, 25% and 0% (100% aggregate) for each of the permutations of RAP and aggregate samples. The tests found that the shear strength decreased with an increase in RAP content supporting Bennert et al.'s results.

Blankenagel et al conducted a study documenting the difference between RCA samples obtained from demolition projects with relatively new RCA samples obtained through batch-plant overruns and haul-backs. The strength of the material was determined immediately after compaction using the California Bearing Ratio test. The demolition RCA and the haul-back RCA had CBR test results of 22% and 55% respectively. Unconfined compressive strength tests conducted on the material were used to determine strength gain over time due to the residual hydration in the RCA. The strength of the demolition material increased 130% and 180% at 3 and 7 days after compaction, respectively. The strength of the haul back material increased 150% to 190% at 3 and 7 days after compaction, respectively. Higher strength gain in the haul back material is most likely due to a greater amount of unreacted cement in the material as well as a finer material gradation. The average 7-day strengths for the demolition and haul-back material were 1260 kPa and 1820 kPa, respectively.

Kuo et al incorporated the use of the Limerock Bearing Ratio (LBR) in Florida to determine the strength of RCA to be used as potential base course. The overall LBR values for the materials tested were 181.71%, which is higher than the required minimum value of 100%. Kim et al(14) studied the effect of RAP content on the resilient modulus of blended aggregate base course. An in-situ blend of FDR was taken during the reconstruction of an existing road along with pure samples of RAP and aggregate materials. The FDR and several blends of the pure RAP and aggregate base material were tested for material stiffness using the resilient modulus test in accordance with NCHRP 1-28A protocol. Blended mixtures of the pure materials were prepared at RAP to aggregate ratios (%/%) of 0/100, 25/75, 50/50 and 75/25. The study found that for an increase in RAP content, the resilient modulus of the blended material increased.(10) The effects of increased RAP content were more defined when the blends were exposed to higher confining pressures, however specimens also experienced higher permanent deformation at 14 higher confining pressures. Specimens tested at 65% optimum moisture content had higher resilient modulus values when compared to specimens prepared at 100% OMC. This trend was consistent for all confining pressures. At low confining pressures (~20kPa), specimens with RAP to aggregate ratios of 50% to 50% and specimens consisting of 100% aggregate had resilient modulus values that were approximately equivalent. As the confining pressures increased, the 50/50 and pure RAP blends became stiffer. The 50/50, 100% RAP and in-situ material tested at the corresponding site had similar resilient modulus values.

4. CRUMB RUBBER TYRES

Crumb rubber is recycled rubber produced from automotive and truck scrap tires. During the recycling process, steel and tire cord (fluff) are removed, leaving tire rubber with a granular consistency. Continued processing with a granulator or cracker mill, possibly with the aid of cryogenics or by mechanical means, reduces the size of the particles further. The particles are sized and classified based on various criteria including color (black only or black and white). The granulate is sized by passing through a screen, the size based on a dimension (1/4 inch) or *mesh* (holes per inch: 10, 20, etc.). Crumb rubber is often used in Astroturf as cushioning, where it is sometimes referred to as astro-dirt.

Fig 1: Crumb Rubber Tyre Powder

5. PROCESSES OF ASPHALT MIX WITH RUBBER TIRES

Scrap tire rubber can be incorporated into asphalt paving mixes using two different methods referred to as the wet process and the dry process. In the wet process, crumb rubber acts as an asphalt cement modifier, while in the dry process, granulated or ground rubber and/or crumb rubber is used as a portion of the fine aggregate. In both cases, crumb rubber is sometimes referred to as crumb rubber modifier (CRM) because its use modifies the properties of the resultant hot mix asphalt concrete product. The wet process can be used for hot mix asphalt paving mixtures, as well as chip seals or surface treatments. The wet process can also be used to prepare rubberized joint and crack sealants, which are not included in the scope of this document. In the wet process, crumb rubber is blended with asphalt cement (usually in the range of 18 to 25 percent rubber) before the binder is added to the aggregate. When asphalt cement and CRM are blended together, the CRM reacting with the asphalt cement swells and softens. This reaction is influenced by the temperature at which the blending occurs, the length of time the temperature remains elevated, the type and amount of mechanical mixing, the size and texture of the CRM, and the aromatic component of the asphalt cement. The reaction itself involves the absorption of aromatic oils from the asphalt cement into the polymer chains that comprise the major structural components of natural and synthetic rubber in CRM. The rate of reaction between CRM and asphalt cement can be increased by enlarging the surface area of the CRM and increasing the temperature of the reaction. The viscosity of the asphalt-CRM blend is the primary parameter that is used to monitor the reaction. The specified reaction time should be the minimum time, at a prescribed temperature, that is required to stabilize the binder viscosity.

When CRM is blended with asphalt cement in the wet process, the modified binder is referred to as asphalt-rubber. To date, most of the experience with the use of CRM in asphalt paving has been with the wet process. Asphalt-rubber binders are used in chip-seal coats as well as hot mix asphalt paving. Chip-seal coat applications using asphalt-rubber binders have become known as stress-absorbing membranes (SAM). When an asphalt-rubber chip seal or SAM is overlaid with hot mix asphalt, the chip seal is referred to as a stress-absorbing membrane interlayer (SAMI). Early applications were batch wet processes and were based on the McDonald technology, which was developed in the early

1960's by Charles McDonald, a City of Phoenix engineer, and in the 1970's by Arizona Refining Company (ARCO). There are numerous patents related to the McDonald technology, some of which have expired and some of which have not. A continuous blending technology was developed in Florida in the late 1980's and is frequently referred to as the Florida wet process. In this process, a fine 0.18 mm (No. 80 sieve) CRM is blended with asphalt cement in a continuous process. The Florida technology differs from the McDonald process in several respects: lower percentages of CRM (from 8 to 10 percent rubber), smaller CRM particle size, lower mixing temperature, and shorter reaction time. The Florida wet process has not as yet been patented. Terminal blending is a wet process with the capability of blending or combining asphalt cement and CRM and holding the product for extended periods of time. This asphalt-rubber product has a shelf life and is blended at an asphalt cement terminal using either batch or continuous blending. Individual state highway agencies are now developing their own products with this technology, since it is not patented. At the present time, none of the terminal blending products has been fully evaluated in the field.

6. HOT-MIX AND WARM-MIX TECHNIQUES

(a) Hot Mix Techniques

This hot asphalt mix is the most common mix used because it can provide great impermeable characteristics allowing water to run away from the surface area. The name comes from the aggregate size used while mixing the raw materials to produce the asphaltic composition. It can also be subdivided as fine-graded or coarse-graded, depending on the majority of the aggregates in the final product. This type of asphalt is **ideal for all traffic conditions**, and has great performance under structural conditions, friction, and for surfacing and repairing needs. This mix was developed to maximize rutting resistance and to have great durability. Due to the process of production, this asphalt mix is more expensive than regular dense-graded mixes. Its design is based on higher asphalt content, modified asphalt binder, and fibers. This asphalt type has been used since 1980's and can be used in numerous road and driveway applications. Due to its high costs, it is recommended to be used on high volume interstate highways to get benefits from its durability and endurance. It will also increase driver's safety due to the impressive friction capabilities with tires; it will also minimize tire noise and will reduce reflective cracking.

Mineral fillers and additives are used to minimize asphalt binder drain-down during construction while increasing the amount of asphalt binder used in the mix and to improve mix durability.

(b) Warm Mix Techniques

Warm-mix asphalt technologies allow the producers of asphalt pavement material to lower the temperatures at which the material is mixed and placed on the road. Reductions of 50° to 100° Fahrenheit have been documented. Such drastic reductions have the obvious benefits of cutting fuel consumption and decreasing the production of greenhouse gases. In addition, engineering benefits include better compaction on the road, the ability to haul paving mix for longer distances, and extending the paving season by being able to pave at lower temperatures.

7. REUSE OF SIW IN ASPHALT PAVEMENTS

One of the major environmental concerns worldwide is the landfill disposals of SIW. Disposals of expired automobile tires and plastics randomly are considered as one of those major causes damaging our ecosystem and posing health problems to all types of life alarmingly. Annually, large volume of tires become exhausted and thrown as wastes frequently seen on the sides of the roads and highways. Also, plastics have been habitually mixed with our municipal solid wastes and sometimes disposed over land areas. And both, in terms of their chemical characteristic represented by their chemical bonds, are very durables and non-biodegradables. As this action continuous to occur, this also calls for implementing very effective management worldwide. The aim is to facilitated technical plans based on control of the toxins resulting from decomposition mostly by means of recycling and reuse of such substances. As a result, many studies and researches have focused on reusing and recycling waste rubber tires and plastics in civil engineering such as in developments and improvements of asphalt surfacing material.

8. Conclusion

This review intended to provide interested readers with the significance of recycling the SIW; it is considered as one of the greatest problems facing the rubber industry today. Our review focused on SIW represented by rubber tires and plastics as tow very effective modifiers for the improvements of asphalt pavement material. The blending of recycled waste rubber tires in the form of CRs and plastics with the asphalt requires a number of experimental factors to be controlled and various techniques to be selected in order to reach improvement in engineering properties of asphalt binder. The number of case studies supplied throughout this paper was sufficient to help readers to be familiar with the different technologies applied of producing and incorporating modifiers in asphalt mixtures that are important in construction of roads with very qualified pavements and improved longevity and pavement performance.

REFERENCES

1. J.-Y. Yu, P.-L. Cong, and S.-P. Wu, "Laboratory Investigation on the Properties of Asphalt Modified with Epoxy Resin," Journal of Applied Polymer Science, vol. 113, pp. 3557–3563, 2009.
2. M. Sienkiewicz, J. K. Lipka, H. Janik, and A. Balas, Waste Management, vol. 32, 2012.

3. S. Rokade, "Use of plastic and waste rubber tires in flexible highway pavements," in Proc. International Conference on Future Environment and Energy, vol. 28, IACSIT Press, Singapoore, 2012.
4. D. D. Carlson and H. Zhu, "Asphalt-Rubber - An Anchor to Crumb Rubber Markets," in Proc. Third Joint UNCTAD/IRSG Workshop on Rubber and the Environment, International Rubber Forum, Veracruz, Mexico, October 7, 1999
5. B. Prusty, "Use of waste polyethylene in bitminous concrete mixes," A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor of Technology in "Civil Engineering", Department of Civil Engineering, NIT Rourkela, National Institute of Technology, Rourkela-769008 (ODISHA), May 2012.
6. R. E. Winters, "The conception and development of asphalt rubber," presented at the National Seminar on Asphalt Rubber, Kansas City Missouri-USA, October 1989.
7. J. E. Huffman, "Sahuaro concept of asphalt-rubber binders," presented at the First Asphalt Rubber User Producer Workshop, Scottsdale Arizona-USA, May 1980.
8. J. A. Epps and B. M. Galloway, (1980), "First Asphalt-Rubber," User-Producer Workshop Proceedings Summary, May 1980.
9. B. Brule, "Polymer-modified Asphalt contents used in the road construction industry: basic principles," Transportation Research Record: J. Transport. Res. Board, vol. 1535. pp. 48-53, 1996.
10. S. Marvridou, N. J Oikonomou, and A. A Kalofotias, "Integration of end-of-life tires in the life cycle of road construction," EU-LIFE+ Environment Policy and Governance, LIFE 09 ENV/GR/304 "ROADTIRE", Thessaloniki, December 2010.
11. F. L. Roberts, P. S. Kandhal, E. R. Brown, and R. L. Dunning, "Investigation and evaluation of ground tire rubber in hot mix asphalt," National Center for Asphalt Technology, NCAT Report No. 89-3, 1989.
12. ASTM (American Society for Testing and Materials), International Annual Book of Standards, D 8 Definitions, 2005.
13. P. E. L. Santucci, "Rubber roads: waste tires find a home, pavement technology update," Technology Transfer Program, vol. 1, issue. 2, Sep. 2009.
14. G. D. Airey, A. C. Collop, and T. M. Singleton, "Rheological and cohesive properties of bitumen cured in crumb rubber," in Proc. the International Symposium of Concrete Technology, University of Dundee, 2001, pp. 281–298.
15. N. Oikonomou and S. Mavridou, "The use of waste tire rubber in civil engineering works," in Sustainability of Construction Materials, J. Khatid, Ed. ch. 9, Woodhead publishing, 2009a, pp. 213-238.
16. J. C. Pais, J. B. Sousa, R. Saam, and P. A. A. Pereire, "Effect of crumb rubber origin on asphalt hot mix laboratory performance," in Proc. 2 and International Symposium on Maintenance and Rehabilitation of Pavements and Technological Control, 29 July – 1 August 2001, Auburn, AL, USA, pp. 1 – 10.
17. V. S. Punith, M. N. Thyagaraj, and A. Veeraragavan, "Studies on tensile strength characteristics of dense bituminous macadam mix with crumb rubber as modifier," in Proc. the 3rd International Conference on Bituminous Mixtures and Pavements, Thessaloniki, Greece, 2002, pp. 547–556.
18. M. M. Rahman, G. D. Airey, and A. C. Collop, "Laboratory investigation to assess moisture sensitivity of dry process CRM asphalt mixtures," in Proc. the International Conference Organized by the Concrete and Masonry Research Group, 2004, pp. 151–162.
19. A. Tortum, C. Celik, and A. C. Aydin, "Determination of the optimum conditions for tire rubber in asphalt concrete," Building and Environment, vol. 40, pp. 1492–1504, 2005.
20. C.-T. Chiu, "Use of ground tire rubber in asphalt pavements: field trial and evaluation in Taiwan," Resources, Conservation and Recycling, vol. 52, no. 3, pp. 522–532, 2008.